GEM 5GHz Progress

May 23, 2001

1 Expected Signal Chain

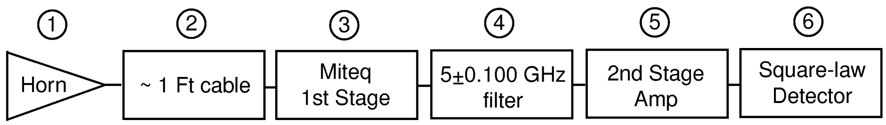

Figure 1: Signal Chain of Feedhorn and 5 GHz Receiver

1.1 Feedhorn

We do have a rough schematic of the feedhorn, and some pictures. I would prefer to have the feedhorn sent up here, so we can fit the cables and such personally, but this may not be possible. Page 5 contains a schematic of the horn and hub, sent from Brazil.

1.2 Cable

We will need at least 1 foot of SMA cable to get from the horn to the 1st stage amp(probably more). We've found cable that will get us $\sim$ 5.6K/Ft. This could easily be doubled in noise/length and/or length, but I'll leave it at that for now: 5.6K (G = 0.98). Note that this low-loss cable has a minimum bend radius of 5cm. See specs page 8.

1.3 Miteq 1st Stage Amplifier

Our Miteq amp(the one we want) has noise temperature 14K at 77K physical temperature. Gain is $10^{3.3} = 1995$. Cost is \$2250. This will be paid by Brazil.

1.4 Filter

Expected filter F_0 insertion loss 2dB. That gives 169K noise temperature. Filter costs range from \$500 to \$600. The most attractive option is a Trilithic filter with insertion loss of less 1.2dB (max) and 40 dBc attenuation at 4820 and 5170 MHz. It costs \$595. See quotations pages 9 and 10.

1.5 2nd Stage Amplifier

2nd stage amplifier could easily give Noise Figure=2.5, Noise Temperature=225K, G=10^3=1000. Assume this. The best quote we have so far is from Quinstar Technology, for gain = 1000, noise temp 120K, \$795. Miteq has an amp, for our purposes equivalent, that costs \$1075. See quotations pages 11 and 12.

1.6 Square-law detector

We know little about detectors. We have one rated for 0.1 to 18GHz.

2 Combined Signal Chain

2.1 System Noise Temperature

The expected noise temperature of the receiver as a whole will be:

$$T_N = T_{horn} + 5.6K + \frac{14K}{0.98} + \frac{169K}{0.98 \times 1998} + \frac{225K}{0.98 \times 1998 \times 0.63} + ...negligible \tag{1}$$

$$T_N = T_{horn} + 20.15 \tag{2}$$

(Don't know what the horn will contribute, but it should be low. Best guess is that the horn contributes negligibly.) System gain:

$$G = 0.98 \times 1998 \times 0.63 \times 1000 = 1.23 \times 10^6 \tag{3}$$

2.2 Gain Stability

We want gain fluctuations to be the order of $\sqrt{\frac{1}{\Delta\nu\tau}}$, $\Delta\nu = 200$ MHz, $\tau = 1$ sec. (That is, we want the gain instability contribution to the minimum detectable temperature to be no more than the contribution from the fundamental noise limit.) Hence $\frac{\Delta G}{G} \approx 7.071 \times 10^{-5}$. This means that the product of gain instabilities must be less than this figure, over a period of one second. For example, if all else is stable, gain from the 1st amp can vary about +/- .07 (out of 1995 total 1st stage gain).

2.3 Sensitivity

If these stability and noise-temperature goals are met, we can expect a sensitivity (minimum detectable temperature) of 2 mK. It is likely that the system temperature will be double the theoretical value. This would yield a sensitivity of 4mK.

3 Physical Layout of Receiver

Pages 6 and 7 contain schematics of what we expect the receiver to look like.

4 Problems

1. We have little way of knowing if the gain stability required is achievable, until we actually put everything together and run some tests.

2. We will need to have some precise schematics of the horn and the dish's hub in order to be able to make the receiver here and have it fit with the existing structure in Brazil. These have not been forthcoming from Brazil.

3. Even with good schematics, getting our big dewar into the small space we have to work with is going to be an issue.

4. We are going to need new sma cable, because the cable we have here is lossy and unreliable. We will also need precision cable to connect the first-stage amp to the horn. Neither sma nor precision cable is meant to be bent by hand. We will either need to order custom items from the manufacturer, or we'll need to get a cable-making kit. Both of these are liable to be expensive, unless we can get ahold of a cable-making kit for free some how.

5 Reference

Noise temp of an attenuator: Kraus Section 7-2b

$$T = \left(\frac{1}{G} - 1\right) T_{phys}$$

Noise temp of Linear Two-ports in Series: Kraus Section 7-2c

$$T = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1 G_2} + \cdots + \frac{T_n}{G_1 \cdots G_n}$$

Sensititivity: Kraus Section 7-1d and 7-1e

$$\Delta T_{min} = T_{sys} \sqrt{\frac{1}{\Delta \nu \tau} + \left(\frac{\Delta G}{G}\right)^2}$$